INDOOR AIR QUALITY ASSESSMENT

Russell Street Elementary School
Russell Street
Littleton, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

April 2003

Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), provided assistance and consultation regarding indoor air quality concerns at the Russell Street Elementary School (RSES) in Littleton, Massachusetts.

On April 2, 2003, a visit was made to this school by Cory Holmes, an Environmental Analyst in the Emergency Response/Indoor Air Quality (ER/IAQ) program, BEHA, to conduct an indoor air quality assessment. Mr. Holmes was accompanied by Bill Meagher, Director of Maintenance, Littleton Public Schools. Accompanied Mr. Holmes for portions of the assessment were Ira Grossman, Health Agent for the Littleton Board of Health; Peter Cassinari, Board of Health Member; Paul Livingston, Littleton Superintendent of Schools; Jane Hall, School Principal and Peter Roache, Business Manager.

The RSES is a two-story brick building constructed in the late 1960's. The second floor contains general classrooms. The first floor has science classrooms, general classrooms, an assembly room, office space, a gymnasium, art room, kitchen, cafeteria and library. Windows are openable throughout the building.

Due to occupant concerns of potential mold growth resulting from on-going roof leaks, the Littleton School Department hired an environmental consultant, Hub Testing Laboratory, Inc. (HUB), to conduct microbial testing. HUB conducted an indoor air quality assessment prior to the BEHA visit. The HUB report recommended that: (1) Room 106 and the library be investigated for standing water and/or pathways for water penetration, (2) any wet materials should be dried, (3) materials that have been colonized by mold should be removed (HUB, 2002).

Methods

Air tests carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school has a student population of approximately 1,200 and a staff of approximately 110. Tests were taken during normal operations at the school and results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in twelve of seventeen areas surveyed, which can indicate a ventilation problem in these areas of the school. Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 1). With the exception of one classroom, all univents are at least thirty-five years old, and were installed during the original construction of the school. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit (see Figure 1).

Univents were operating in all classrooms surveyed. Obstructions to airflow, such as papers and books stored on univents and bookcases, carts and desks in front of univent returns, were seen in a number of classrooms (see Picture 2). In order for univents to provide fresh air as designed, intakes must remain free of obstructions.

Exhaust ventilation in classrooms is provided by a mechanical system. The exhaust system in each classroom consists of ducted, grated wall vents, which create draw of air through rooftop motors. Exhaust ventilation was functioning in all classrooms surveyed. A number of the vents were blocked by desks, bookcases, shelving and in some cases open doors (see Pictures 3 & 4). The location of exhaust vents in some classrooms can also limit exhaust efficiency when the classroom hallway door is open. When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom (see Picture 5). The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms. As with the univents, in order to function properly, exhaust vents must remain free of obstructions.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The physical/occupational therapy room has no means of mechanical ventilation or openable windows. BEHA staff recommended installing passive vents in the doors to enhance airflow. Without ventilation, indoor air pollutants can build up and lead to indoor air quality/comfort complaints, especially in an area of physical activity.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings were measured in a range of 66^{o} F to 72^{o} F, which were below the BEHA comfort guidelines in some areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in this building ranged from 27 to 34 percent, which was below the BEHA recommended comfort range in all areas surveyed. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The building has a history of roof leaks. Active roof leaks were reported in a number of areas throughout the school including the gym, cafeteria, a number of classrooms, the art room, hallways and in the “Tiger’s Den”, which houses an after school program for students. Water-damaged ceiling tiles, walls and other building materials were observed (see Pictures 6-8). In some cases tiles in the suspended ceiling tile system have collapsed due to water saturation from roof leaks. School maintenance personnel have also disconnected electrical utilities and removed light fixtures due to water contact (see Picture 9). Water leakage in classrooms and common areas is collected by buckets, trashcans, tarpaulins and in Picture 10, empty instrument cases. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

Pooling water was observed in a number of areas on the roof (see Picture 11). The freezing and thawing of water during winter months can lead to roof leaks and subsequent water penetration into the interior of the building. Pooling water can also become stagnant, which can lead to unpleasant odors and microbial growth. In addition, stagnant pools of water can serve as a breeding ground for mosquitoes.

BEHA staff examined the roof and found the rubber membrane to be rippled, brittle, and cracked in a number of areas (see Pictures 12-14). This breach of the building envelope that can allow water penetration into the building. It was reported by school officials that attempts were made to repair and replace some sections of the roof. These attempts did not, however remove old damaged roof, but covered the existing roof with new layers of material. School officials reported that plans have been discussed for replacement of the roof; which will include the removal of all existing roof layers.

Also noted on the roof was the absence of catch basins/strainers around roof drains (see Picture 15), which can allow the drains to become clogged easily. The east wing roof only had three drains, which appeared to be inadequate. Many areas had damaged flashing along roof edges/seams that allow water to accumulate against the building (see Picture 16).

Exterior caulking around windows and frames was crumbling/damaged in a number of areas and condensation was noted between windowpanes indicating that the water seal is no longer intact (see Pictures 17-19). A probe was inserted approximately six inches into the space around a classroom window frame, to demonstrate a potential pathway for wind driven rain to enter interior wall space (see Picture 20). Replacement of caulking and repairs of window leaks are necessary to prevent water penetration. Repeated water damage can result in mold colonization of porous building materials and items stored on or around windowsills. Missing/damaged caulking around univent air intakes was also noted, which can provide another source of water penetration as well as pest migration (see Picture 21).

Expansion joints around the exterior of the building may also be contributing to water penetration. A sealant compound was inserted into each joint to prevent water penetration. Expansion joint sealant was weathered, mechanically damaged or missing. (see Pictures 22 & 23). Sections of missing or damaged expansion joint sealant can serve as means for water entering during driving rains. These breaches can also allow for entry of insects, rodents and other pests into the building.

The exterior walls had spaces/cracks in brickwork. In many areas mortar around exterior brickwork appears to be crumbling or missing. These conditions are breaches of the building envelope and provide a means for water entry into the building. Repeated water penetration can result in the chronic wetting of building materials and the potential for microbial growth.

Small trees and other plants were also seen growing against the foundation. Clinging plants were observed growing on exterior walls. The growth of roots against the exterior of foundation walls, as well as spaces between the tarmac, can bring moisture in contact with brick and foundation structures, which may eventually lead to moisture penetration below ground level areas of the building. Bushes/shrubs around the perimeter of the building were observed in close proximity to univent air intakes. Shrubbery can be a source of moisture, mold and pollen and should be relocated to prevent entrainment into fresh air intakes.

Several classrooms contained a number of plants. Plant soil and drip pans can serve as a source of mold growth. Plants and potting soil were found on top of univents in several classrooms. Plants should be located away from the air stream of univents to prevent aerosolization of dirt, pollen or mold. In a former science room, abandoned sinks were filled with potting soil and being used as planters. Without drainage, over watering can lead to possible microbial growth in these sinks.

Signs of bird roosting and nesting materials were observed in the casings of window-mounted air conditioners around the exterior of the building. These units should be thoroughly cleaned and disinfected prior to operation. Birds can be a source of disease, and bird wastes and feathers can contain mold and mildew, which can be irritating to the respiratory system. No obvious signs of bird roosting inside the building or in ventilation components were noted by BEHA staff nor were they reported by occupants.

Other Concerns

Several other conditions that can potentially affect indoor air quality were identified. Accumulated chalk dust and dry erase board particulate was noted in several classrooms. Chalk dust and dry erase board particulates can be easily aerosolized and serve as eye and respiratory irritants. In addition, materials such as dry erase markers and dry erase board cleaners may contain VOCs (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can also be irritating to the eyes, nose and throat.

As discussed, several areas contained window-mounted air conditioners and some classrooms contained portable air purifiers. This equipment is normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

Open utility holes were noted in a number of areas (see Picture 24). Open utility holes can provide a pathway for the movement of drafts, odors and particulate matter between rooms and floors.

Spray cleaning products were found on floors and countertops in several classrooms. Cleaning products contain chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

A number of classrooms contained upholstered furniture, cushions and large pillows. These items are covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US

EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, M.A., 1994). It is also recommended that upholstered furniture (if present in schools), be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000). Increased cleaning is needed since upholstered furniture in classrooms would have increased use by multiple individuals as compared to a home setting.

In an effort to reduce noise from sliding chairs, tennis balls are sliced open and placed on chair legs. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and to off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix II (NIOSH, 1998).

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate. These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Finally, a number of wasp's nests were observed along the perimeter of the building. Under current Massachusetts law, effective November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in state buildings and grounds (Mass Act, 2000).

Conclusions/Recommendations

The conditions noted at the RSES raise a number of indoor air quality issues. The combination of the general building conditions, maintenance, design and limits due to the age of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Follow recommendations listed in the HUB report (HUB, 2002). Remove any mold colonized material a manner consistent with US EPA recommendations for mold remediation (US EPA, 2001).
2. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a

heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers throughout the school.

3. To maximize air exchange, the BEHA recommends that all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) operate continuously during periods of school occupancy independent of thermostat control. To increase airflow in classrooms, set univent controls to “high”.
4. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
5. Install passive vents in doors of PT/OT room. Consider installing a local exhaust vent in the exterior wall to provide air circulation.
6. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.
7. Supplement airflow in classrooms by using openable windows to control for comfort. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
8. Remove bird’s nests and inspect air conditioning units. Clean and disinfect housing of bird wastes and rinse with soap and water prior to operation.
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water

during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

10. Move plants away from univents in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary. Consider discontinuing the use of abandoned sinks as planters.
11. Remove plant growths against the exterior wall/foundation of the building to prevent water penetration.
12. Seal utility holes in classrooms, to prevent the egress of odors and particulate matter into classrooms.
13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
14. Clean chalkboards and dry erase board trays regularly to avoid the build-up of particulates.
15. Change filters for window-mounted air conditioners, air-handling equipment and air purifiers as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates.
16. Consider developing a written notification system for building occupants to report indoor air quality issues/problems. Have these concerns relayed to the maintenance department/ building management in a manner to allow for a timely remediation of the problem.

17. It is highly recommended that the principles of integrated pest management (IPM) be used to rid this building of pests. A copy of the IPM recommendations can be downloaded from the Internet at http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf.
18. Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation.
19. In order to maintain a good indoor air quality environment on the building, consideration should be give to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
20. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

The following **long-term measures** should be considered:

1. Continue with plans for roof replacement including the removal of historical "patches". Once roof is repaired, replace any remaining water-stained ceiling tiles and other water damaged building materials. Examine the area above and around these areas for microbial growth. Disinfect areas of water leaks with an appropriate antimicrobial.
2. Examine the feasibility of enhancing drainage to areas of the roof subject to water pooling (e.g. east wing roof). This may include redirecting the pitch of the roof towards drains or installation of new drains.

3. Based on the age, physical deterioration and availability of parts of the HVAC system, the BEHA strongly recommends that the HVAC engineering firm fully evaluate the ventilation system for proper operation, and/or repair/replacement considerations.
4. Consider having exterior brick re-pointed and waterproofed to prevent water. intrusion. This measure should include a full building envelope evaluation.
5. Repair and/or replace thermostats and pneumatic controls as necessary to maintain control of thermal comfort. Consider contacting an HVAC engineer concerning the condition and calibration of thermostats and pneumatic controls school-wide.
6. Repair/replace loose/broken windowpanes and missing or damaged window caulking building-wide to prevent water penetration through window frames. During this project it is recommended that all water-damaged materials be examined for microbial growth and structural integrity. Repair water damaged ceilings, walls and wall-plaster as necessary.

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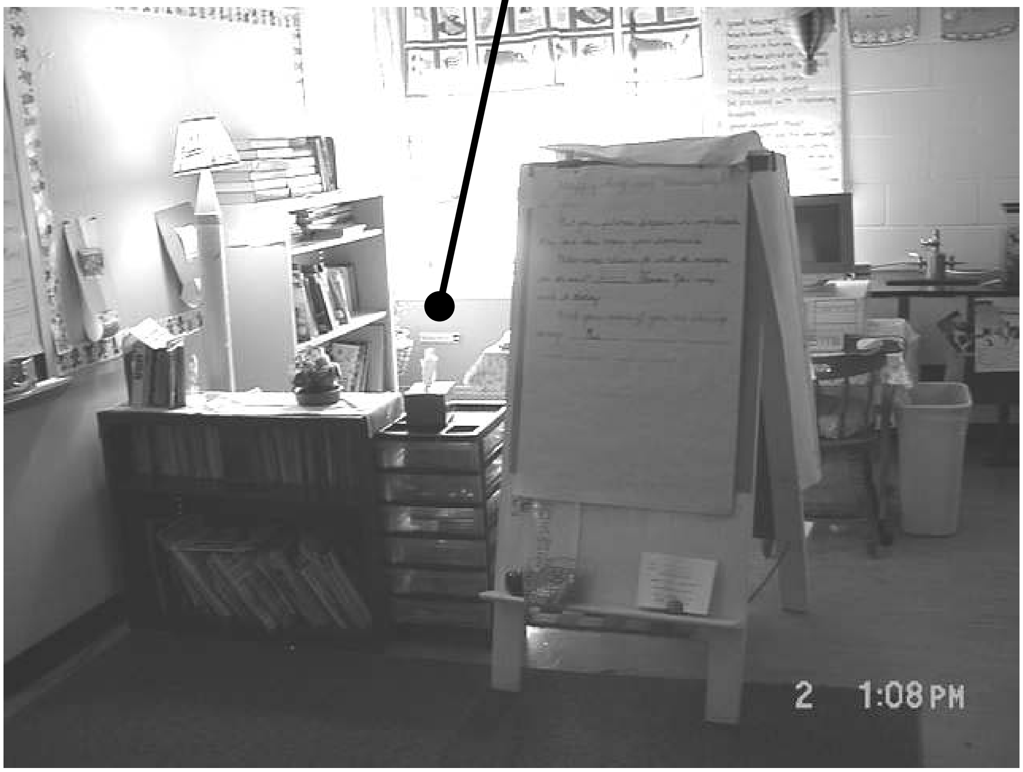
Picture 1

Classroom Univent, Note Flowering Plants on Top of Unit Near Air Diffuser

Picture 2

Univent



Items in Classroom Obstructing Airflow of Univent

Picture 3

Classroom Exhaust Vent Partially Obstructed

Picture 4

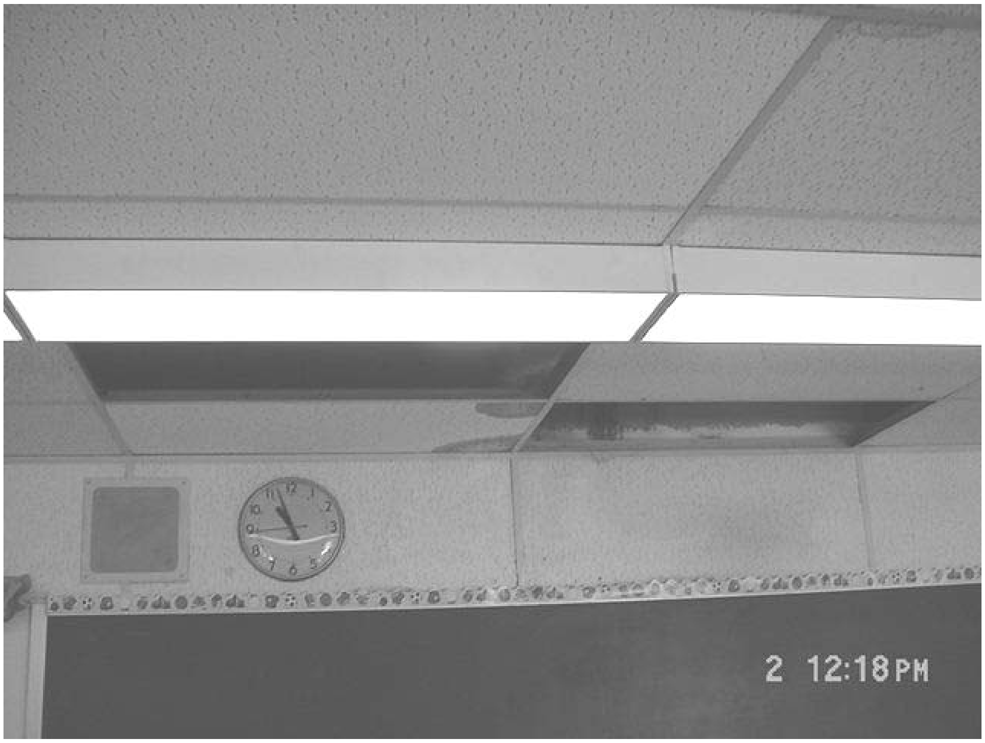
Classroom Exhaust Vent Obstructed When Hallway Door is Opened

Picture 5

Open Hallway Door

Proximity of Classroom Exhaust Vent to Hallway Door

Picture 6

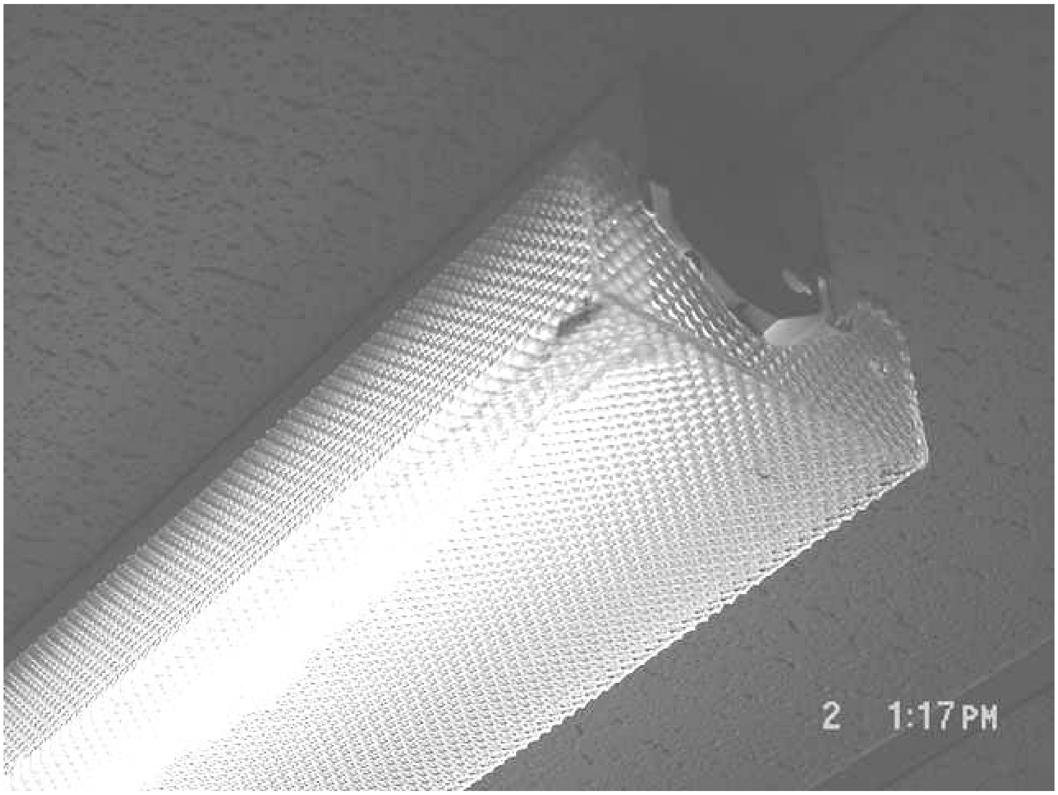


Missing/Water Damaged Ceiling Tiles in Classroom

Picture 7

Missing/Water Damaged Ceiling Tiles in First Floor Hallway

Picture 8



Staining Inside Light Fixture From Accumulated Water

Picture 9

Light Fixture Disconnected and Partially Removed Due to Water Damage

Picture 10

**Plastic Sheeting on Floor, Buckets, Trash Cans and Instrument Cases
To Collect Water Leaks from Roof**

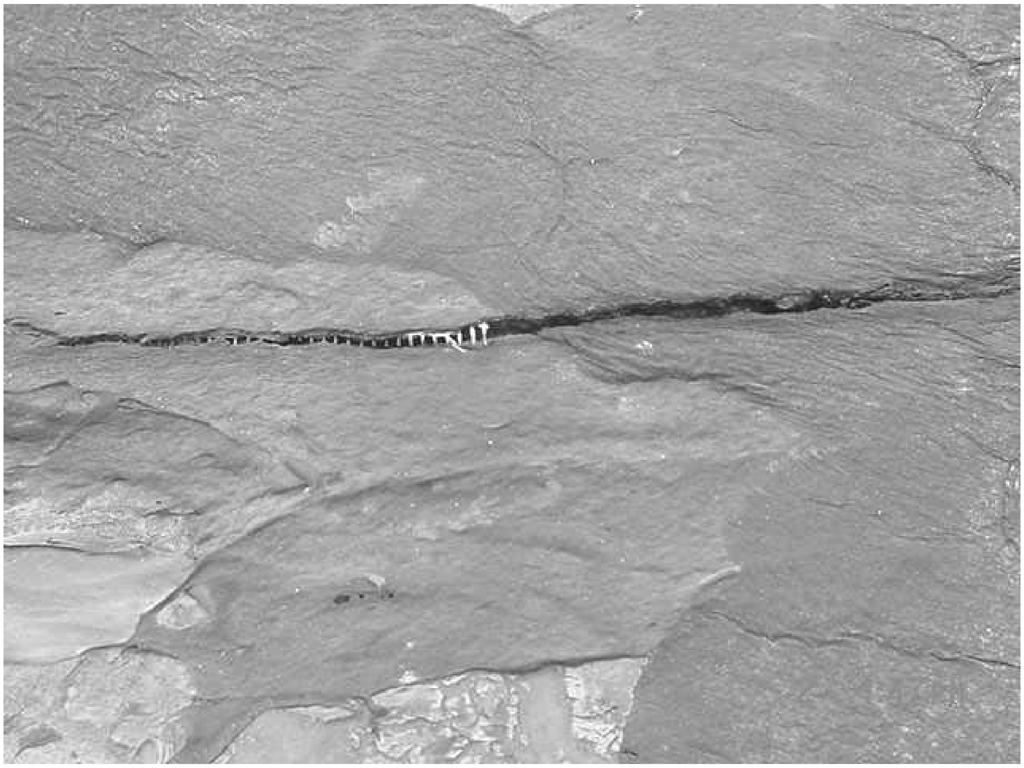
Picture 11

Pooling Water, Leaves and Debris on Roof Near Univent Air Intake

Picture 11

Warped, Rippled Roof Membrane, Note Water Pooling Between Grooves

Picture 13

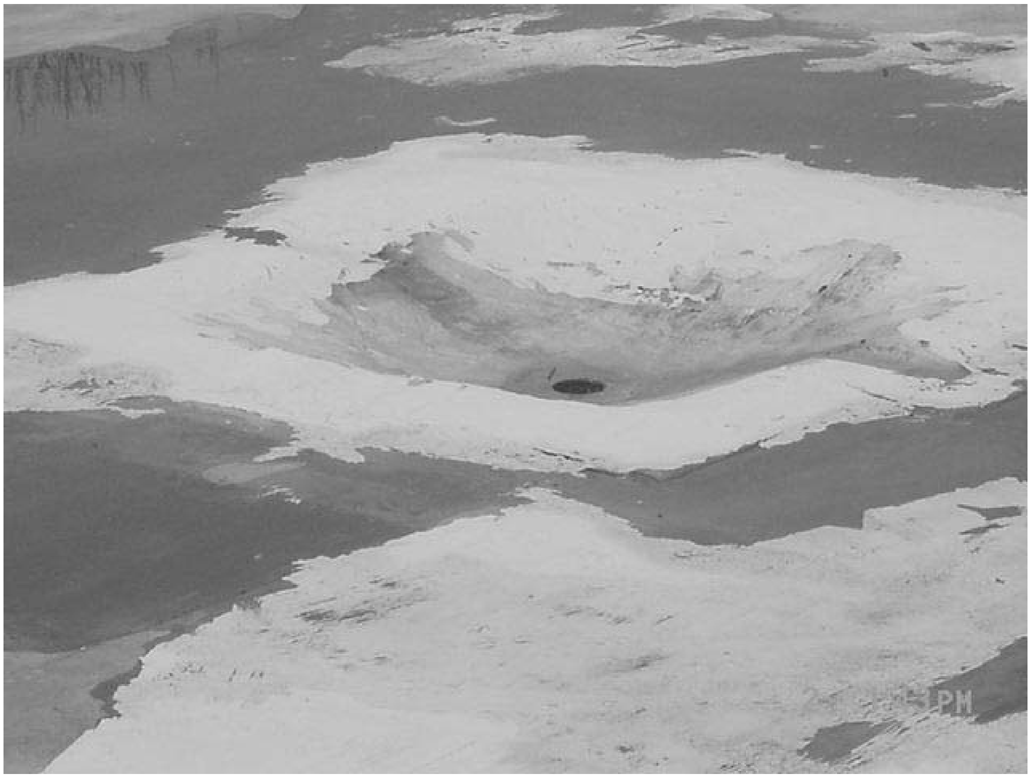


Large Crack in Roof Membrane Exposing Wire Mesh Matrix beneath

Picture 14

Crack in Roof Membrane That Runs Length of Roof

Picture 15



Roof Drain, Note Lack of Strainer/Catch Basin

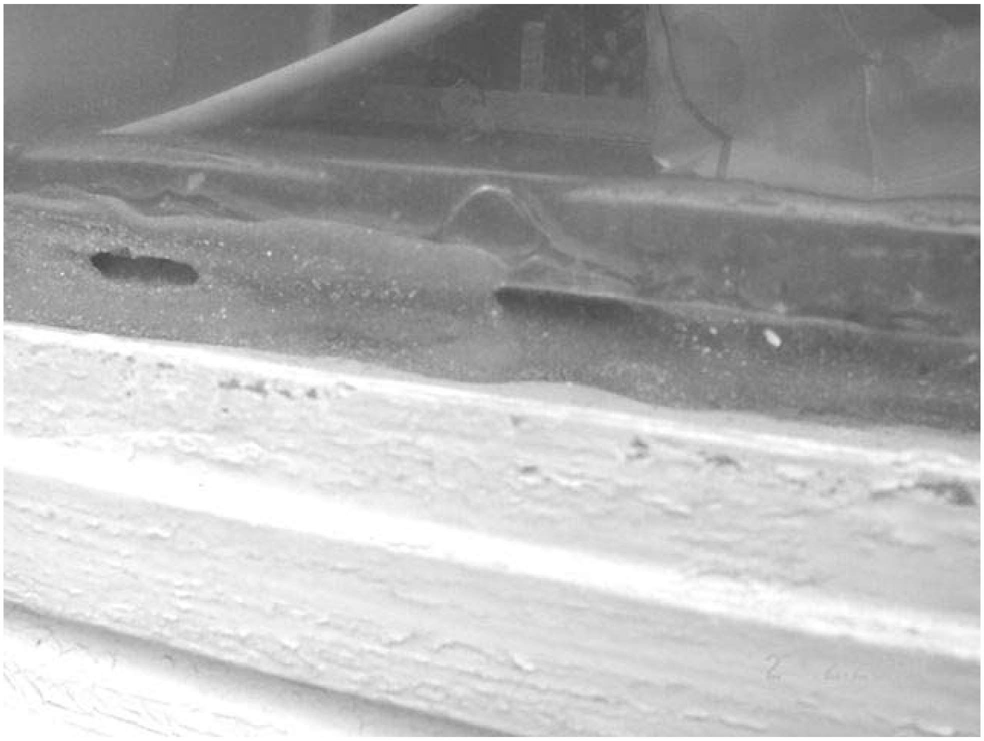
Picture 16

Damaged Flashing Along Roof Junction

Picture 17

Missing Damaged Caulking around Window Frame

Picture 18



Missing Damaged Caulking around Window Pane, Note the Bottom of Glass Exposed

Picture 19

Condensation Between Double Paned Windows in Classroom

Picture 20

Probe Inserted Into Space around Window Frame Missing Caulking

Picture 21

Missing Damaged Caulking around Univent Air Intake

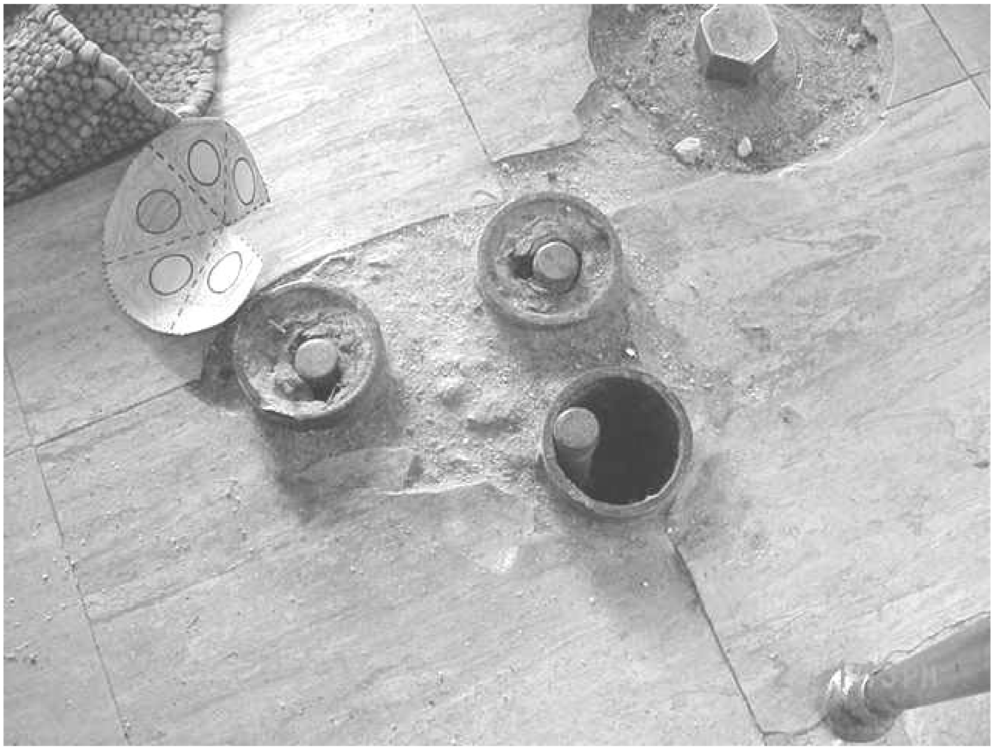
Picture 22

Missing/Damaged Expansion Joint Sealant

Picture 23

Missing/Damaged Expansion Joint Sealant, Note Large Hole in Foundation Can Provide Entry for Pests

Picture 24



Open Utility Holes in Floor of Classroom 106

TABLE 1

Indoor Air Test Results – Russell Street Elementary School, Littleton, Massachusetts– April 2, 2003

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	413	49	29					Sunshine, scattered clouds
Room 210	1064	69	29	27	Y	Y	Y	Tennis balls, air tank
Room 212	1008	72	28	29	Y	Y	Y	Chalk dust, items on UV/plants, air purifier on floor, open utility holes, electrical outlet, WD leaks, dry erase board particulate in trey
Room 213								Unoccupied due to excessive water leakage/illness
Room 214	1035	72	30	26	Y	Y	Y	CT along exterior wall, peeling wallpaper, exhaust partially blocked, items hanging from CT system
Room 216								Hallway outside room 216 Active leak – bucket, roof drain
Room 216	979	70	28	26	Y			Exhaust vent blocked, 5 CT Condensation – window sills
Room 211	1264	71	29	26	Y	Y	Y	CT 10
Room 202	725	68	27	22	Y	Y	Y	Plant near UV return, WD wall tiles, exhaust vent behind door

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles
UV - Univent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Russell Street Elementary School, Littleton, Massachusetts– April 2, 2003

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 102	1142	71	32	23	Y	Y	Y	Flowering plants on UV Plant matter in air diffuser Cleaning product on floor
Room 101	1033	70	30	22	Y	Y	Y	Plants, tennis balls, exhaust vent blocked
Room 104	1112	71	33	22				Plants on UV, exhaust vent behind cabinet
Room 103	1342	69	32	24	Y	Y	Y	Old sinks used as planters
PT/OT	1131	71	31	0	N	N	N	Recommend passive vent in door
Prep Room	1052	71	31	5	N	N	Y	Missing ceiling tiles
Room 106	896	70	29	6	Y	Y	Y	Aquarium, tennis balls, air purifier on floor, open pipes - floor utility holes
Assembly	451	70	27	0	N	Y	Y	UV – dirt/soot like deposits on air diffuser, dust accumulation inside vent
Nurses Office	691	69	32	2	N	N	Y	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles
UV - Univent

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TABLE 3

Indoor Air Test Results – Russell Street Elementary School, Littleton, Massachusetts– April 2, 2003

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Art Room Hallway								Leak from roof down internal wall
Roof Notes								Rippling/warping roof membrane, east wing few drains, no strainers/catch basins, kitchen maint/roof pooling/leaves, large cracks/seams, membrane brittle
Cafeteria	664	66	34	60	N	Y	Y	Leaks interior wall, dust accumulation exhaust vent
Stage Area								Active leaks, tarps, buckets, barrels, instrument cases for catch basin
Gym Hallway								Active leaks
Gym	540	70	29	0	N	Y	Y	Leaks from roof drain and along roof seam in interior wall, deteriorating gym mats-source of particulates
Tigers Den Office Area	610	71	32	1	Y	Y	Y	After school room, roof leaks interior wall

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles
UV - Univent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
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TABLE 4

Indoor Air Test Results – Russell Street Elementary School, Littleton, Massachusetts– April 2, 2003

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Perimeter notes								Open seams, cracks in brick, corroded metal exterior doors, missing/damaged caulking around window frames, univent air intakes, plant growth against foundation, clinging plants on brickwork, wasp/bees nests under roof eaves, shrubbery in front of univent air intakes, leaking faucet against foundation

* ppm = parts per million parts of air
CT = water-damaged ceiling tiles
UV - Univent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%